Ch-4- Moving Charges and Magnetism

Force on moving charge in uniform magnetic and electric field.

Home Assignment :

Q1. If a particle of charge q is moving with velocity v along the z-axis and the magnetic field B is acting along the x-axis, use the expression $\vec{F} = q(\vec{v} \times \vec{B})$ to find the direction of the force F acting on it.
A beam of proton passes undeflected with a horizontal velocity v, through a region of electric and magnetic fields, mutually perpendicular to each other and normal to the direction of the beam. If the magnitudes of the electric and magnetic fields are 100 KV/m and 50 mT respectively. Calculate

a) velocity v of the beam.
b) the force with which it strikes a target on a screen if the proton beam cutting is equal to 0.80 mA.

Ans 1. $\vec{F} = q(\vec{v} \times \vec{B})$

$\vec{v} = v\hat{k}$ and $\vec{B} = B\hat{i}$

$\vec{F} = q(v\hat{k}) \times (B\hat{i})$

$\vec{F} = qvB\hat{j}$ $\quad (\hat{k} \times \hat{i} = \hat{j})$

∴ Force is acting along the y-axis.

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a/c $V = \frac{E}{B}$

$= 2 \times 10^3 \text{ V/m}$

$, 5 \times 10^{-3} \text{ T}$

$= 2 \times 10^3 \times 10^3 \text{ m/s}$

$= 2 \times 10^6 \text{ m/s}$

b/c

Q2. A beam of α-particles projected along $+X$ axis, experiences a force due to magnetic field along the $+Y$ axis. What is the direction of the magnetic field?

Ans 2. $\vec{F} = q(\vec{V} \times \vec{B})$

$= q V B \sin\theta$

$B = \frac{F}{qV\sin\theta}$

$q = 1, v = 1, \theta = 90°, \sin 90° = 1$

then $B = F$

The direction of $\vec{F}$ is the direction of cross-product of velocity $\vec{V}$ and magnetic field $\vec{B}$, which is perpendicular to the plane containing $\vec{V}$ and $\vec{B}$.

∴ From the cross-product rule and Right-hand rule

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The direction of magnetic field is along +Z axis.

Q3. Define one tesla using the expression the magnetic force acting on a particle charge q moving with velocity v in a magnetic field B.

Ans 3. $\vec{F} = q(\vec{v} \times \vec{B}) = qvB\sin\theta$

$B = \frac{F}{qv\sin\theta}$

If $F = 1N$, $q = 1C$, $v = 1m/s$, $\theta = 90°$ then

S.I unit of $B = \frac{1N}{1C \cdot 1m/s \cdot \sin 90°}$

$= \frac{1}{N} = \frac{1N}{1A \cdot 1m} = 1NA^{-1}m^{-1}$

$= 1$ tesla.

One tesla is the magnetic field in which charge of 1C moving with a velocity of 1m/s normal to the magnetic field experiences a force of 1N.

Q4. A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency

Ans 4. Mass of electron is low as compared to proton. Hence, when both enter into the uniform magnetic region, the electron will move in a circular path with higher frequency in the opposite direction to the current.

Q5. Three protons of equal kinetic energies enter a region of uniform magnetic field. The first proton enters normal to the field direction while the second enters at 30° to the field direction. Name the trajectories followed by them.

Ans 5: For the first proton, $F = qvB\sin 90°$

$= qvB$ which is maximum

It follows circular trajectory.

For second proton, $F = qvB\sin 30° = qvB \times \frac{1}{\sqrt{3}}$

It follows helical trajectory.